Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band	)	GN Docket No. 12-354

COMMENTS OF ALCATEL-LUCENT

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Alcatel-Lucent submits these comments in response to the above-captioned Notice of Proposed Rulemaking ("NPRM") seeking comment on service rules for unlocking the potential for shared use of the 3550-3650 MHz band.[1]

I. INTRODUCTION AND SUMMARY

Alcatel-Lucent is the trusted transformation partner of service providers, enterprises, and strategic industries worldwide, providing solutions to deliver voice, data and video communications services to end-users. A leader in mobile, fixed, IP and optics technologies, and a pioneer in applications and services, Alcatel-Lucent was named on *MIT Technology Review*'s 2012 Top 50 list of the "World's Most Innovative Companies"[2] for breakthroughs such as its small cell, lightRadio™ technology, which cuts power consumption and operating costs on wireless networks while delivering lightning fast Internet access. Alcatel-Lucent currently sells a portfolio of small cell products with 3G, Long Term Evolution ("LTE") as well as WiFi capability, Automatic Network Discovery and Selection Function ("ANDSF") gateways for enabling WiFi/3G/4G handovers and host-neutral – device neutral platforms for use

[1] *Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650- MHz Band*, GN Docket No. 12-268, FCC 12-148 (rel. Dec. 12, 2012) ("NPRM").

the world over. Alcatel-Lucent also is at the forefront in exploring dynamic spectrum sharing arrangements[3] and use of whitespace spectrum in small cells,[4] and participates in each of the Commerce Spectrum Management Advisory Committee's Working Groups to collaborate with the United States Government and other industry representatives on sharing solutions in spectrum bands currently allocated for Federal government use.[5] Alcatel-Lucent leverages the unrivaled technical and scientific expertise of Bell Labs, a leading innovator in the communications industry.

Alcatel-Lucent appreciates the Commission's recognition of the benefits of small cells to mobile networks generally, as well as for the 3.5 GHz band. While exploration of small cells in the 3.5 GHz band is relatively new, the value of small cell technology in other bands, throughout the wireless ecosystem, is well recognized. Alcatel-Lucent's LightRadio is a key enabler of network densification, one of many technologies carriers are deploying to squeeze every ounce of utility out of their spectrum holdings. By adding small cells to their networks, carriers are supplementing existing macrocell deployments with cells closer to end users to permit greater "reuse" of scarce wireless frequencies. Small cells also are an excellent tool to fill

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[2] *See* MIT Technology Review, 50 Disruptive Companies, available at http://www2.technologyreview.com/tr50/2012/, visited Jan. 21, 2013.

[3] *See, e.g.*, M. Buddhikot, P. Kolodzy, S. Miller, K. Ryan and J. Evans, DIMSUMnet: New Directions in Wireless Networking Using Coordinated Dynamic Spectrum Access, Bell Labs Technical Report, Sept 2003, Updated Oct 2004. Accessed Feb. 5, 2013 at: http://www.bell-labs.com/user/mbuddhikot/dimsumnet/index.htm.

[3] S. Sen, T. Zhang, M. Buddhikot, S. Banerjee, D. Samardzija, S. Walker, A Dual Technology Femto Cell Architecture for Robust Communication using Whitespaces (Best Paper Award), Proceedings of IEEE DySPAN 2012, Seattle, Oct 16-19, 2012, Accessed Feb. 19, 2013 at http://www.bell-labs.com/user/mbuddhikot/psdocs/DySPAN12-Whitecells-2012.pdf.

[5] *See* CSMAC Working Groups List, Jul. 24, 2012, Accessed Feb. 19, 2013 at *http://www.ntia.doc.gov/other-publication/2012/csmac-working-groups-list.*

in coverage gaps and offer the promise of assisting with offloading traffic from congested networks, rerouting traffic to landline networks.

In this proceeding, the Commission has recognized that the low power technology deployed in small cells may unlock the 3.5 GHz band. Indeed, due to incumbent government uses that will remain in the band, the NPRM notes that higher power commercial WiMAX technologies would result in expansive exclusion zones, excluding approximately 60% of the U.S. population from the benefits of services in the band.[6] In contrast, by leveraging lower power small cells, and given the short propagation characteristics of the band, the Commission proposes to significantly shrink those exclusion zones and substantially increase the value of the band for non-Federal use. To quote Commissioner Rosenworcel in her statement to the NPRM: "How cool is that?"[7]

While open to the Commission's approach to the 3.5 GHz band, there are several changes to the Commission's proposal that Alcatel-Lucent believes will enhance it. In particular, Alcatel-Lucent urges the Commission to not be overly prescriptive in place of market forces. The Commission should allow the market to unfold without placing undue restrictions on uses of the band and formulate rules that allow experimentation with multiple use cases. For example, to the extent commercial wireless operators seek access to the band, their services may require quality of service guarantees. As a consequence, the Commission should not prescribe an arbitrary class of entities that are eligible for "priority" use of the band, but rather should permit any entity that desires a higher-quality of service in the band to seek that priority access. Wireless access, traffic offload and non-line-of-sight ("NLOS") backhaul are examples of potential carrier uses in the band, not all of which are enabled by the Commission's proposal.

[6] NPRM at ¶ 114-115.

Alcatel-Lucent further requests that the Commission not seek to arbitrarily set power limits across the band. Different parameters may be appropriate across different geographies and topographies, and depending on indoor or outdoor uses. The Commission's proposal to establish a Spectrum Access System ("SAS") is recommended as a means to maximize non-incumbent use of the band. It is of great importance that the SAS has access to complete, up-to-date information. There are several methods for entities to gain access to the band to ensure it is put to its best use, including through commercial fees or through auction. Alcatel-Lucent further recommends that this band is likely most amenable to Time Division Duplexing ("TDD") due in large part to the relatively large duplex gap that would be required for Frequency Division Duplexing ("FDD") at this frequency.

A critical component to unlocking the utility of the 3.5 GHz band is gaining as much information as possible about incumbent Federal uses of the band. Further study of exclusion zones during incumbent operations, data regarding temporal usage patterns by Federal incumbents and the like are critical to maximizing the value of this band for non-Federal operations.

II. THE COMMISSION SHOULD PERMIT INNOVATION AND EXPERIMENTATION

A. The Commission Should Not Limit "Prioritized" Access to Niche Users

In the NPRM, the Commission proposes a "multi-tier" spectrum access framework which would include a priority access tier (Tier 2) for limited categories of users and suggests such users may be "hospitals, utilities, state and local governments and/or other users."[8] The Commission also anticipates that priority access users will operate primarily indoors.

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[7] NPRM, attached Statement of Commissioner Jessica Rosenworcel.

[8] NPRM at ¶ 9.

Alcatel-Lucent urges the Commission to not reserve high-quality uses of this band to a subset of potential users, or indoor-only scenarios. Rather, Alcatel-Lucent asserts that a superior approach would be for *all* non-incumbent users to be eligible to participate in the priority access tier, subject to the same benefits and responsibilities in the band. For example, any class of user that demands wireless services with high quality of service guarantees, high reliability and availability should be eligible to obtain such access. Cellular operators would be among the entities that would have such needs. Without the capability to gain "priority" access to the band, any operator contemplating developing expensive infrastructure to use this band would necessarily worry that new primary services may emerge that might eliminate secondary resources and essentially strand any investment for secondary use.

Furthermore, Alcatel-Lucent urges the Commission not to limit priority use of the band to areas where "no interference from incumbent operations would be reasonably anticipated."[9] It is one thing to ensure incumbent users are protected from commercial uses in the band, it is quite another to tell a class of users they are not permitted to operate in an area because they would be subject to a level of interference *from* incumbent users. It should be up to the authorized user to determine whether a given level of interference is acceptable for its operations.

Even in those geographies where there are incumbent operations that might materially impair non-incumbent uses, those incumbent operations might not operate every hour of every day. Today's sharing techniques are sufficiently dynamic that certain geographies would offer high-quality service opportunities, while signaling users to move to other frequencies during times of incumbent use. Many of these capabilities hinge on the quality and

[9] NPRM at ¶ 70.

timeliness of information provided to the SAS, as discussed further below. The record in this proceeding, including further investigation into incumbent uses, will better define the market opportunity for priority use of the band, including *inside* areas previously designated as "exclusion zones."

B. Potential Carrier Uses of the 3.5 GHz Band

Alcatel-Lucent believes that, among the potential uses of the band, the 3.5 GHz band presents an opportunity for deployment of fixed wireless access, wireless backhaul for small cells, indoors and outdoor small cell, or perhaps even macrocellular use in regions far from incumbent users.

Specifically, the 3.5 GHz band could be utilized for fixed wireless broadband access in rural and semi-urban areas leveraging outdoor small cells. Where technologies such as Phantom DSL, pioneered by Alcatel-Lucent,[10] or Fiber-to-the-Node, Curb, or Home ("FTTx") may not be cost-effective or feasible, wireless solutions offer another tool for bolstering broadband access. Verizon's Home-Fusion[11] is an example of a wireless broadband solution being used as a fixed-line substitute. Access to the 3.5 GHz band, along with a system to ensure high quality of service, could be instrumental in enabling similar offerings.

Service providers in the Americas are rolling out heterogeneous networks ("HetNets") where outdoor small cells ("micro" and "metro" cells) and indoor small cells ("femto" and "pico" cells) are embedded in the coverage area of macrocells. As detailed in a 4G Americas whitepaper, small cells and macrocells can share the same channels (spectrum bands)

[10] *See* Alcatel-Lucent, Innovations in Broadband Access: Phantom Mode, accessed Feb. 19, 2013 at http://www.alcatel-lucent.com/products/phantom-mode.

in the carrier's licensed bands for added spectral efficiency.[12] The resulting interference interaction across macro and small cell layers needs to be controlled to achieve optimal performance, and Alcatel-Lucent small cell products, for example, already support cutting edge solutions for such interference management. Small cell deployments are supported with co-channels, "soft-reuse" of co-channels, as well as separate channels. Consequently, the 3.5 GHz band may be particularly useful for small cell use -- especially the priority access portion -- as an additional "offload" resource in a HetNet.

The 3.5 GHz band also could be employed for wireless backhaul, solving an important impediment to greater small cell deployment. Small cell technology is a promising part of the solution to the spectrum crunch. However, availability of backhaul to connect small cells into a carrier's network is critical to its widespread rollout.

Because of their small size and visual profile, small cells are expected to be deployed on a large variety of sites far beyond rooftops, including bus stops, advertising panels, sidewalls of buildings, traffic signals, utility poles, etc. Such deployments are often at a height ranging from 8 to 20 feet. Greater heights require careful and expensive site acquisition, more expensive installation, and higher labor costs (training, equipment, insurance, etc.).

While the ease of deployment of small cells is a very attractive feature of the technology, it also poses challenges with respect to backhaul. Putting small cells in arbitrary places, and in far larger numbers than macrocells, makes the cost of providing wireline backhaul

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[11] "HomeFusion Broadband From Verizon Powers In-Home Internet Connectivity With 4G LTE," Verizon press release of March 6, 2012, accessed Feb. 14, 2013: http://news.verizonwireless.com/news/2012/03/pr2012-03-05f.html.

[12] *See* 4G Americas Whitepaper, Developing and Integrating a High Performance HET-NET, October 2012 ("4G Americas Whitepaper") accessed Feb. 12, 2013 at: http://www.4gamericas.org/documents/4G%20Americas%20-Developing%20Integrating%20High%20Performance%20HET-NET%20October%202012.pdf.

an expensive proposition. In fact, in many cases, the cost of deploying wireline backhaul may exceed the cost of the small cell. Therefore, an inexpensive wireless backhaul solution would be an valuable tool for facilitating large scale deployment of small cells. In the absence of such a solution, small cell deployment may be limited to locations where wireline backhaul is available.

Traditional wireless backhaul solutions, such as line-of-site ("LOS") backhaul provide challenges in a small cell setting. Deployment of small cells at heights 20 feet or lower puts them in "a clutter environment" with significant obstacles (e.g., vehicles, buses, trucks, buildings, trees). Traditional microwave backhaul solutions at 28/60/80 GHz (mmWave solutions) require line of site that is often not available due to this clutter. In contrast, in sub-6 GHz spectrum bands, NLOS backhaul is feasible, as it can better penetrate obstacles described above.

Therein lies the challenge. Since large swaths of dedicated spectrum below 3 GHz are not available, a solution must be identified in spectrum bands between 3 to 6 GHz. 3.5 GHz represents an ideal band. For this reason, Alcatel-Lucent urges the Commission to allow 3.5 GHz to be used for short range (< 2 km) NLOS backhaul. Using large scale Multiple Input Multiple Output ("MIMO") technology, Alcatel-Lucent can deliver cost effective high capacity backhaul solutions that use low transmit powers over such distances. As an additional note, because of the small size of the 3.5 GHz small cell antennas, 2x2, 4x4 and even 8x8 MIMO TRX radios can be built quite cost effectively to deliver high capacity for fixed and mobile broadband and NLOS backhaul applications. To that end, Alcatel-Lucent urges the Commission's service rules in the band to support deployment of multi-antenna systems.

By allowing NLOS backhaul use in the 3.5 GHz band in addition to access use, the Commission can help create an important tool promoting robust small cell deployment to begin with.

C. 3.5 GHz Power Limits Should Not Be Set Artificially or Arbitrarily Across an Entire Geography

While low power technologies have the capability to substantially increasing the utility of the 3.5 GHz band, it is important to clarify that small cells have uses in many bands. Millions of small cells have already been installed in the U.S. market outside of 3.5 GHz. Most of these are indoor residential units, but many thousands of moderate power (<5 Watts of RF transmit power) are also being installed.[13] There should be no doubt that small cells are an important and currently commercial approach to addressing the spectrum crunch and the burgeoning demand for wireless broadband access. In the spirit of being flexible to allow experimentation and aggressive spectrum use, the Commission should not be too prescriptive in terms of maximum power limits and allow SAS to calculate the same on a spatial and temporal basis. This will allow small cells that may have sufficiently large coverage and help increase their value proposition in many rural and semi-urban markets.

In terms of coordinating with Federal users, the SAS, described in greater detail below, can be made to coordinate the power and class of base station, including indoor or outdoor small cells, and even macrocells provided they are sufficiently far from Federal users.

In regions where there are Federal users of the spectrum, even intermittent use, the constraints on power, antenna orientation (tilt as well as azimuth) and times of operations, will likely make the economics of installing macrocells less attractive compared to small cells.

[13] *See* 4G Americas Whitepaper, *supra* note 12.

Closer to the Federal coordination zones, perhaps only indoor small cells of lower power may be all that is economical. The market, aided with coordination studies with the SAS, can determine appropriate tradeoffs and zones of applicability for various classes of wireless base stations.

D. SAS Is an Appropriate Way to Manage Use of the Band

In the NPRM, the Commission proposes to enable a "Spectrum Access System" in the 3.5 GHz band. Alcatel-Lucent agrees that a SAS is an appropriate mechanism to manage use of this band. The SAS must not only protect incumbent Federal operations, but should also protect secondary users from each other, and should provide sufficient information to allow secondary users to protect themselves from incumbent operations. Otherwise, secondary users' spectral efficiency will be reduced and the directive to use the spectrum to maximum benefit will not be met.[14]

In order for secondary operations to be coordinated amongst themselves, the SAS needs to have timely information about other nearby or co-channel radios in the geographic area. This is best facilitated with a single SAS "spectrum broker." Alternatively, the Commission should require that all SAS database managers share information, at least on a query basis, with other SAS entities, and to share this information at predictably quick speeds. Any outage by one will cause interference to the uses of other SASs.

The SAS mechanism is amenable to several alternative arrangements for ensuring the spectrum is put to the most valuable use. For example, secondary rights might be auctioned for maximum economic utility. Given the local exclusion zones required for separation from

[14] This has not been the approach taken with the rollout of TV whitespace technologies, which have multiple spectrum database managers and currently no protection for secondary users coordinated among the various database managers.

various federal fixed use and occasional federal mobile use (e.g. Naval RADAR) the geographic areas for these auctions ought to be regional in size ("REAs"). The auction would express the market's sense of the value of the spectral resources in different markets and with the expected impact of the primary license holder's operations. An auction of the secondary licenses provides the license holders with maximum certainty with respect to longer-term spectrum rights and quality of service.

Alternatively, it is conceivable for a SAS to essentially auction off spectral resources in time and geography to near continuously seek to maximize the spectrum utilization, perhaps even on a time scale measured in seconds. Similarly, in place of an auction, an access fee could be charged for guaranteed access. The auction-based and fee-based models both would provide a way to monetize SAS operations. Such access models can meet multiple objectives of efficient use of spectrum, high quality of communications and revenue generation.

E. SAS Database Must Be Complete and Updated in Real-Time

Given the importance of the SAS and its database, this rulemaking should consider methods to ensure the SAS database incorporates accurate and timely information on spectrum occupancy, including incumbent spectrum occupancy. The innovative potential of this rulemaking will be diminished if the incumbent tier spectrum usage records in SAS overinflate their spectrum use in spatial and temporal dimensions. This can artificially diminish spectrum availability and attractiveness of spectrum in the band for non-Federal use.

Ensuring the SAS has complete temporal use information is just as important as complete geographic information, as temporal usage patterns could cause certain geographic exclusion zones to disappear completely when spectrum is not in use by the incumbent user. Permitting dynamic SAS technologies will spur innovation in such technologies furthering

efforts to most efficiently use scarce spectrum resources. Similar considerations apply to non-incumbent users. In general, a light weight mechanism to track and record spectrum usage in SAS will improve spectrum utilization, anomaly detection, strengthen security and improve revenue potential.

F. TDD Is Recommended for 3.5 GHz Operations

Alcatel-Lucent recommends that the 3.5 GHz band should be reserved for TDD service. Any pairing of spectrum for uplink and downlink as in FDD would greatly suffer from SAS reassignments of one link or the other as primary users come on-line or various secondary users move about. At this relatively high frequency, a duplex gap would require tens of MHz to accommodate the temperature and manufacturing variation that is proportional to the frequency, likely in excess of 54 MHz – over half the spectrum included in the 3.5 GHz band - using the 1.5% "challenging" rule of the IWPC's Mobile filter Group.[15] The large duplex gap required for FDD argues in favor of TDD in this band.[16]

TDD does pose certain obstacles, but we believe they can be managed in this band. TDD use requires adjacent carriers to use the same timing parameters (in both phases), cadence, and compatible duty cycles. Otherwise, a radio on one carrier may be transmitting full power while a nearby radio on an adjacent carrier may be listening with full sensitivity. This interference scenario causes both out-of-band blocking, as well as leakage into adjacent bands. To ameliorate these problems would require filters which, at this frequency, would be impractical without substantial guard bands between the various carriers. Consequently, all

[15] IWPC Mobile RF Filter Group, Docket No. 12-268 (filed Nov. 27, 2012).

[16] Alcatel-Lucent similarly does not recommend coexistence of FDD and TDD in this band. Strictly speaking, unidirectional transmissions could be used, such as with carrier aggregation

operators in this 3550-3650 MHz band would need to operate with coordinated timing parameters, with common disciplined timing sources such as GPS.

The coordination required among TDD authorized users can be done through private agreements, but because these are likely to be needed nation-wide (because geographically contiguous co-channel license must be coordinated in this way) it may be best to require that the SAS manage the timing parameters as well as the frequency, scheduling and space resources.

Alcatel-Lucent cautions that the Commission should not mandate a specific duty cycle and cadence in its rules, but rather permit situational flexibility. The desired timing parameters are evolving as different smart phone applications consume more or less downlink traffic relative to uplink traffic. There are also venues such as the Super Bowl at which an unusual amount of uplink traffic is produced as attendees upload many photos while creating relatively little downlink traffic. At such an event, the SAS might assign timing parameters that accommodate uplink traffic, while in the surrounding neighborhoods, the more typical downlink-intensive timing parameters would still be used. The parking lot around the stadium would serve as a buffer zone where the timing parameters would conflict but where there may be relatively little demand during the event. As the event ends, the timing parameters can be returned to normal. Such flexibility could substantially increase the utility of the band.

G. Air Interface Protocol for 3.5 GHz operations

Alcatel-Lucent urges the Commission to not mandate use of a particular type of Media Access protocol in 3.5 GHz band. Specifically, the Commission should not mandate use

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schemes where the alternate direction transmissions can be handled in a wholly different frequency band. But we take such downlink-only proposals as a special case of TDD.

of Wi-Fi like contention resolution based random access protocols to the exclusion of other technologies. Though Wi-Fi may be suited for certain operations, the priority access portion of 3.5 GHz may be ideally suited for synchronous air interface protocols such as TD-LTE that provide high spectral efficiency and support priority traffic classes. The rapid growth in the world-wide LTE device ecosystem makes possible cost-effective support of the 3.5 GHz band and, potentially, commercial adoption by mobile operators.

III. FURTHER STUDY OF INCUMBENT OPERATIONS IS REQUIRED

Alcatel-Lucent cautions that detailed technical studies using simulation tools and testbeds are essential to characterize various aspects of three tier spectrum sharing advocated in this proceeding.

Specifically, topics such as the size of exclusion zones, spatio-temporal characteristics of incumbent interference to secondary users, aggregate interference caused by low power small cells in configurations of various density, and impact of SAS lease grant and termination events require careful study. For independent study of these and other issues, industry and academia require greater understanding of incumbent transmitter characteristics and their usage patterns. Given that some of this information may be classified, Alcatel-Lucent urges FCC and NTIA to establish a process for industry-government information sharing. Experience with current CSMAC working group efforts demonstrates that this is not a simple process, but these are necessary steps.

IV. CONCLUSION

For the forgoing reasons, Alcatel-Lucent fully supports the Commission's efforts to facilitate non-Federal operations in the 3.5 GHz band.

Respectfully submitted,

Alcatel-Lucent

/s/

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